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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a r qu st f r filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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08/11/03

INVENTOR(S)

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☑ Additional inventors are being named on the 1 separately numbered sheets attached hereto

TITLE OF THE INVENTION (500 characters max)

Magnetic Torque Transfer Device

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ENCLOSED APPLICATION PARTS ***(check all that apply)***

☑ Specification Number of Pages 14
☑ Drawing(s) Number of Sheets 6
☑ Application Data Sheet. See 37 CFR 1.76
☐ CD(s), Number
☐ Other (specify)

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.
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Respectfully submitted,

SIGNATURE [signature]

Date 07/28/2003

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Additional Page

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Docket Number	

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Number 1 of 1

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MAGNETIC TORQUE TRANSFER DEVICE

[001] BACKGROUND OF THE INVENTION

[002] There has been great interest in the use of magnetic rheological fluid (MRF) technology for the development of products in recent years including the automotive industry. MRF is a fluid that contains minute particles of iron in a carrier fluid. The MR fluid becomes nearly a solid when subjected to a magnetic field. Much of the interest in the automotive industry had been related to clutches and brakes. At least one MRF device has been developed and is near serial production for vehicles. Despite this, the application of MRF to clutches and brakes has several serious drawbacks that limit its future applications. These are:

[003] Low torque capability relative to other technology commonly used,

[004] Separation of the iron particles from the carrier fluid when the device is rotation at high speed,

[005] Parasitic drag losses, and

[006] High cost for a specific torque capability versus other technology.

SUMMARY OF THE PRESENT INVENTION

[007] It is the first object of the present invention to provide a new and improved assembly that overcomes the previously delineated drawbacks of present MRF application technology.

[008] It is the second object of the present invention to provide an improved clutch or brake that transmits torque equal to or exceeding other conventional technology of equivalent size.

[009] It is the third object of the present invention to provide a clutch or brake that has faster and more accurate response that can be achieved with conventional technology.

[0010] It is the fourth object of the present invention to provide a clutch or brake that is less expensive to manufacture than a clutch or brake that uses conventional technology.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is a schematic of prior MRF application technology.

[0012] Figure 2 is a general view of the present patent used as a clutch.

[0013] Figure 3 is cross-sectional view A-A of Figure 1.

[0014] Figure 4 is cross-sectional view B-B of Figure 1.

[0015] Figure 5 is an enlarged view of pinion shaft seals.

[0016] Figure 6 is a general view of the present patent used as a brake.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE PRESENT INVENTION

[0017] Figure 1 shows a schematic of a typical MRF clutch. The input element is 100 and the output element is 101. The MR fluid is 102. Assuming the input element 100 is rotating faster than the output element, when the MR fluid 102 is subjected to a magnetic field it becomes nearly a solid. There is basically no clearance between input element 100 and MR fluid 102 and there is basically no clearance between MR fluid 102 and output element 101. Torque is transmitted through the shearing of the magnetic flux between the input and output elements and the MR fluid when the actuating coil is energized. Separation of the iron particles can be a problem if the assembly is rotated at high speed for a long time. Transmitted parasitic torque (drag) when the actuating coil is not energized can also be a problem in some applications. If element 101 is stationary, it would be a brake and the same action occurs.

[0018] Figure 2 is a general view of the present patent 10 used as a clutch. Element 12 is the input shaft of the present invention and is typically splined. Output shaft 13 is also typically splined and is integral with output housing 19. Said output housing and elements 15, 16, 17 and 18 rotate with output shaft 13. Slip ring assembly 14 is stationary and connects the stationary power supply with the output elements to provide current for the actuation coils contained therein.

[0019] Figure 3 is cross-sectional view A-A of Figure 1. Input shaft 12 is integral with input driver 30. This driver has four bored holes at 90 degrees apart for bushings 25. These bushings support one end of pinion shafts 24. Space 49 between the ends of the pinion shafts 24 and input driver 30 and end flange 32 is filled with grease for permanent lubrication of bushings 25. End flange 32 has identical bored holes as input driver 30 for bushings 25 to support the opposite end of pinion shafts 24. Each pinion shaft has involute teeth as shown in Figure 4. These teeth mesh with the internal teeth of the cylindrical extension 20 of driven flange 18 with a backlash (clearance) of approximately one-half millimeter (.020"). Grooves 23 are provided in extension 20 for proper control of the electrical flux field.

[0020] Spacer 33 is constructed of aluminum or other non-magnetic material and has an integral flange 48 on one end for attachment to input driver 30 with appropriate dowels and screws. The shape of said spacer other than said flange is shown in Figure 4.

[0021] Flange 31 attaches to spacer 33 and bushing housing 32 attaches to flange 32. The input assembly is supported on the input end by sealed bearing 35 and by sealed bearing 28 on the opposite end. Retaining ring 36 keeps bearing 35 in its correct position and retaining ring 47 keeps bearing 28 in its correct position. Input end housing 15 mounts to coil housing 17 and supports sealed bearing 35.

Output shaft 13 is integral with output housing 19 and has cylindrical extension 50 to mount sealed bearing 28.

[0022] Electrical coils 21 mount on the outside of cylindrical extension 20 and are separated from the MR fluid by it. Coil housing 17 contains coils 21 and provides the necessary flux path. O rings 22 seal the assembly against any leakage of the MR fluid.

[0023] Slip ring 41 is attached to input end housing 15 and retains sealed bearing 35. Said slip ring incorporates bronze bushings 43 that are in contact with brushes 38. Springs 38 urge brushes 38 against bushings 43 to maintain good electrical contact. Slip ring housing 37 is stationary and supported on slip ring 31 by sealed bearing 44. Slip ring housing 37 is split at one centerline and held together by screws 48. Cover 40 retains springs 38 and provides access of the electrical leads to the assembly.

[0024] Figure 4 is cross-sectional view B-B of Figure 1. As stated above, spacer 33 is constructed or non-magnetic material. Pole pieces 51 are steel for magnetic flux path control and are attached to spacer 33 by screws 52. The assembly is filled with MR fluid so the fluid fills the angular space between cylindrical extension 20 and surfaces 53 of pole pieces 51.

[0025] Figure 5 is an enlarged view of the pinion shaft seals. Element 27 is a standard piston ring with overlapping end construction. Piston ring 27 is a tight fit in flange 48 because of the nature and design of piston rings. Surfaces 49 in pinion shaft 24 form a close clearance fit with piston ring 27. In operation, piston ring 27 is rotationally fixed relative to flange 48. This construction makes an effective

seal against the ingress of MR fluid to seal 26. This is important because this fluid causes premature wear with contact to the sealing lip of seal 26. Seal 26 is a commercially available seal that can withstand pressures up to 25 bar which is much higher than the pressure of the grease used for lubrication of bushing 25 due to centrifugal force. Piston rings 29 and 34 provide seals against the ingress of MR fluid to sealed ball bearings 28 and 36.

[0026] Figure 6 is a general of the present patent 200 when used as a brake. Element 212 is the input shaft of the present invention and can be splined as shown or have keyways. Elements 215, 216, 217, 218 and 219 are stationary. The internal components are the same as described in the discussion for Figure 3 except that no slip ring assembly is required.

OPERATION

[0027] Reference is again made to Figure 4. Assume the rotation of spacer 33 which is connected to input shaft 12 is as shown by arrow 33. If coils 21 are not energized, pinion shafts 24 rotation in the direction of arrow 61 and coils 21 and coil cover 17 that are connected to output shaft 13 do not rotate. The vast majority of the MR fluid circulates within the unit as shown by arrow 63. The small amount of MR fluid 64 will pass through the meshes of pinion shaft 24 teeth and the teeth in cylinder extension 20 because of the large backlash (clearance) between them and

be directed to grooves 23 in cylindrical extension 20. This rotation of the pinion shafts keeps the iron particles in the MR fluid mixed with the carrier fluid.

[0028] Parasitic drag losses of the present patent are very low compared to MRF clutches using conventional application technology. One reason for this is the small physical size of the present invention compared to conventional application technology. The second reason is that a small portion of the total surface areas within the present patent has a small gap between adjacent moving parts. Parasitic losses between adjacent moving surface are inversely proportional to the square of the gap distance.

[0029] When coils 21 are fully energized, MR fluid 64 becomes almost a solid and blocks the revolution of teeth of pinion shafts 24. This causes the cylindrical extension 20 and thus the output shaft to rotate in the same direction and at the same speed as the input shaft when the output load is equal or less than the torque rating of the present invention. For some applications such as vehicle torque management of power from the transmission to the rear wheels, high-speed engagement is essential for proper performance. The present invention can transmit full rated torque in as little as 50 milliseconds for a clutch with a torque of 1500 Nm. The torque capability of the present invention is 25 or more times the torque capability of a clutch of the same dimensions using conventional MRF application technology. For example, a clutch with a torque capacity of 1500 Nm (1106 lbs-ft) is 160 millimeters (6.29 inches) in diameter and 200 millimeters (7.87 inches) long.

[0030] Soft engagement of the present invention is sometimes required such as its application as the vehicle's main clutch that is mounted between the engine and the transmission. This soft engagement is accomplished by gradually increasing the current applied to coils 21 to the current required to transmit the desired torque. The torque required when the present invention is used as the vehicle's main clutch can be for example 550 Nm (405 lbs-ft). The size of the present invention is much smaller than the conventional dry-friction clutch.

[0031] It is to be understood that the invention is not to be limited to the exact construction and/or method that has been illustrated and is discussed above, but that various changes and/or modifications may be made without departing from the spirit and the scope of the invention.

CLAIMS

What is claimed:

1. A high-torque magnetic device consisting of:

   a rotating input assembly with integral input shaft,

   at least two pinion shafts with gear teeth disposed radialy about the centerline of input assembly,

   a rotating output assembly with integral output shaft,

   internal gear teeth in output assembly that mesh with gear teeth of pinion shafts of input assembly, and

   magnetic rheological fluid that partially fills internal cavity.

2. High-torque magnetic device of claim 1 wherein the rotating output assembly contains electrical coils.

3. High-torque magnetic device of claim 1 wherein rotation of input shaft does not rotate output shaft.

4. High-torque magnetic device of claim 1 wherein current applied to electrical coils solidifies a portion of the magnetic rheological fluid contained within the cavity to

block motion between gear teeth contained in input assembly with gear teeth in output assembly.

5. High-torque magnetic device of claim 4 wherein a high torque load at output shaft rotates when input shaft rotates.

6. High-torque magnetic device of claim 4 wherein a soft engagement between the input assembly and output assembly is achieved by slowly increasing the current applied to electrical coils.

7. High-torque magnetic device of claims 1-6 wherein the rotation of the pinion shafts of input assembly mixes the magnetic rheological fluid when input shaft and output shaft are revolving at different speeds thereby keeping the iron particles in the fluid from separation that occurs due to centrifugal force without a mixing means.

8. High-torque magnetic device of claims 1-7 that uses standard piston rings as a highly efficient labyrinth to keep magnetic rheological fluid from bearings and bushings.

9. A high-torque magnetic device consisting of:

   a rotating input assembly with integral driving flange for attachment to a flywheel or similar part,

   a rotating output assembly with integral output shaft,

at least two pinion shafts with gear teeth disposed radialy about the centerline of output assembly,

internal gear teeth in input assembly that mesh with gear teeth of pinion shafts of output assembly, and

magnetic rheological fluid that partially fills internal cavity.

10. High-torque magnetic device of claim 9 wherein the rotating input assembly contains electrical coils.

11. High-torque magnetic device of claim 9 wherein rotation of input driving flange does not rotate output shaft.

12. High-torque magnetic device of claim 9 wherein current applied to electrical coils solidifies a portion of the magnetic rheological fluid contained within the cavity to block motion between gear teeth contained in output assembly with gear teeth in input assembly.

13. High-torque magnetic device of claim 12 wherein a high torque load at output shaft rotates when input driving flange rotates.

14. High-torque magnetic device of claim 12 wherein a soft engagement between input assembly and output assembly is achieved by slowly increasing the current applied to electrical coils.

15. High-torque magnetic device of claims 9-14 wherein the rotation of the pinion shafts of output assembly mixes the magnetic rheological fluid when input driving flange and output shaft are revolving at different speeds thereby keeping the iron particles in the fluid from separation that occurs due to centrifugal force4 without a mixing means.

16. High-torque magnetic device of claims 9-15 that uses standard piston rings as a highly efficient labyrinth to keep magnetic rheological fluid from bearings and bushings.

17. High-torque magnetic device of claims 1-16 wherein the compressive strength of magnetic rheological fluid when subjected to magnetic flux is utilized to transmit torque from an input assembly to an output assembly.

18. High-torque magnetic device of claims 1-8 and 17 whose physical size and performance makes it suitable for power management between a vehicle's transmission and wheels.

19. High-torque magnetic device of claims 9-17 whose physical size and performance makes it suitable as a vehicle's main clutch that is mounted between the vehicle's engine and transmission that is smaller in physical size and weight than conventional clutches used for this purpose.

20. A high-torque magnetic device consisting of:

a rotating input assembly with integral input shaft,

at least two pinion shafts with gear teeth disposed radialy about the centerline of input assembly,

a stationery assembly with internal gear teeth that mesh with gear teeth of pinion shafts of input assembly, and

magnetic rheological fluid that partially fills internal cavity.

21. High-torque magnetic device of claim 20 wherein the stationery assembly contains electrical coils.

22. High-torque magnetic device of claim 20 wherein the input shaft is free to rotate.

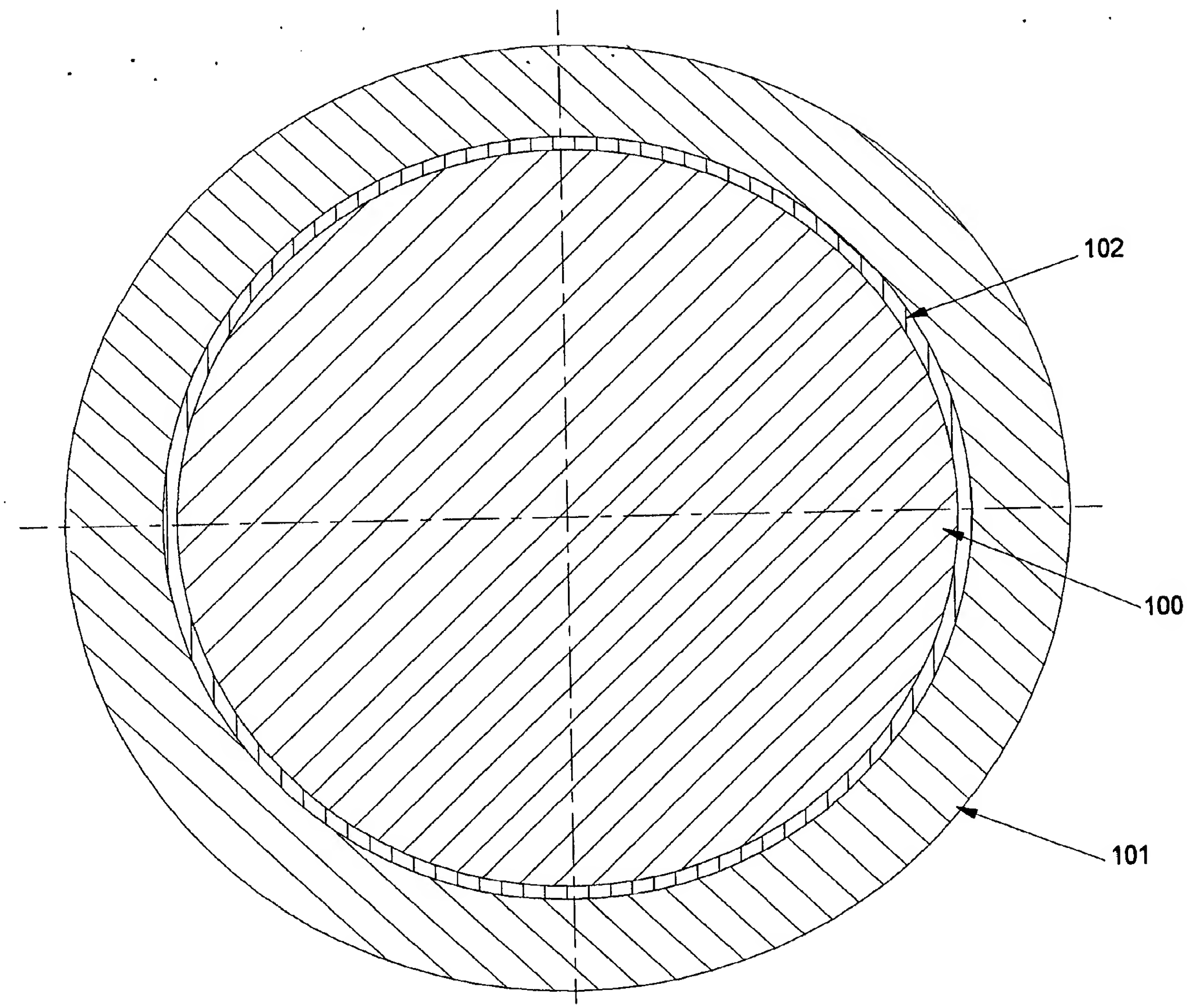
23. High-torque magnetic device of claim 20 wherein current applied to electrical coils solidifies a portion of the magnetic rheological contained within the cavity to block motion between gear teeth contained in input assembly with gear teeth in stationery assembly.

24. High-torque magnetic device of claim 23 wherein a load that requires high torque and connected to input shaft is stopped.

25. High-torque magnetic device of claim 23 wherein soft stopping of the load connected to the input shaft is achieved by slowly increasing the current applied to electrical coils.

26. High-torque magnetic device of claims 20-25 that uses standard piston rings as a highly efficient labyrinth to keep magnetic rheological fluid from bearings and bushings.

27. High-torque magnetic device of claims 20-26 wherein the compressive strength of magnetic rheological fluid when subjected to magnetic flux is utilized to stop rotating loads.



PRIOR ART

FIGURE 1

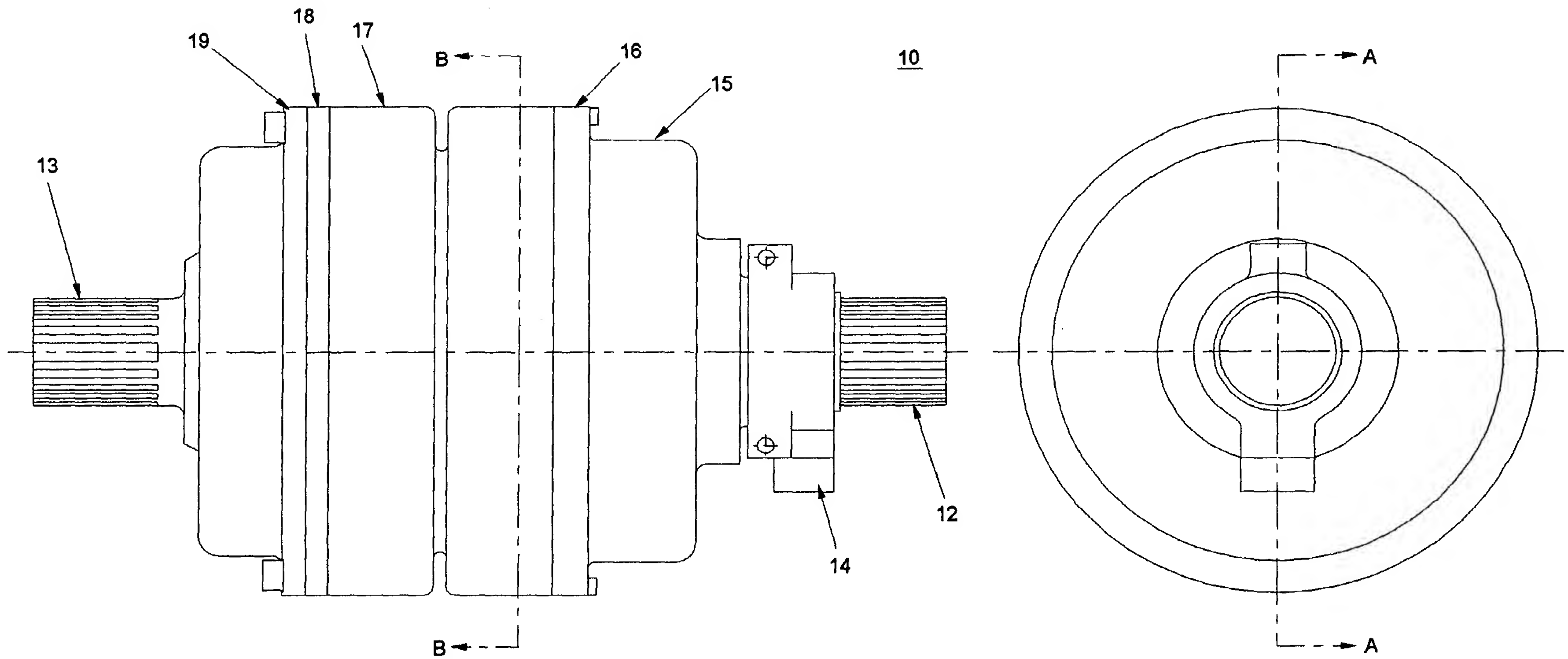


FIGURE 2

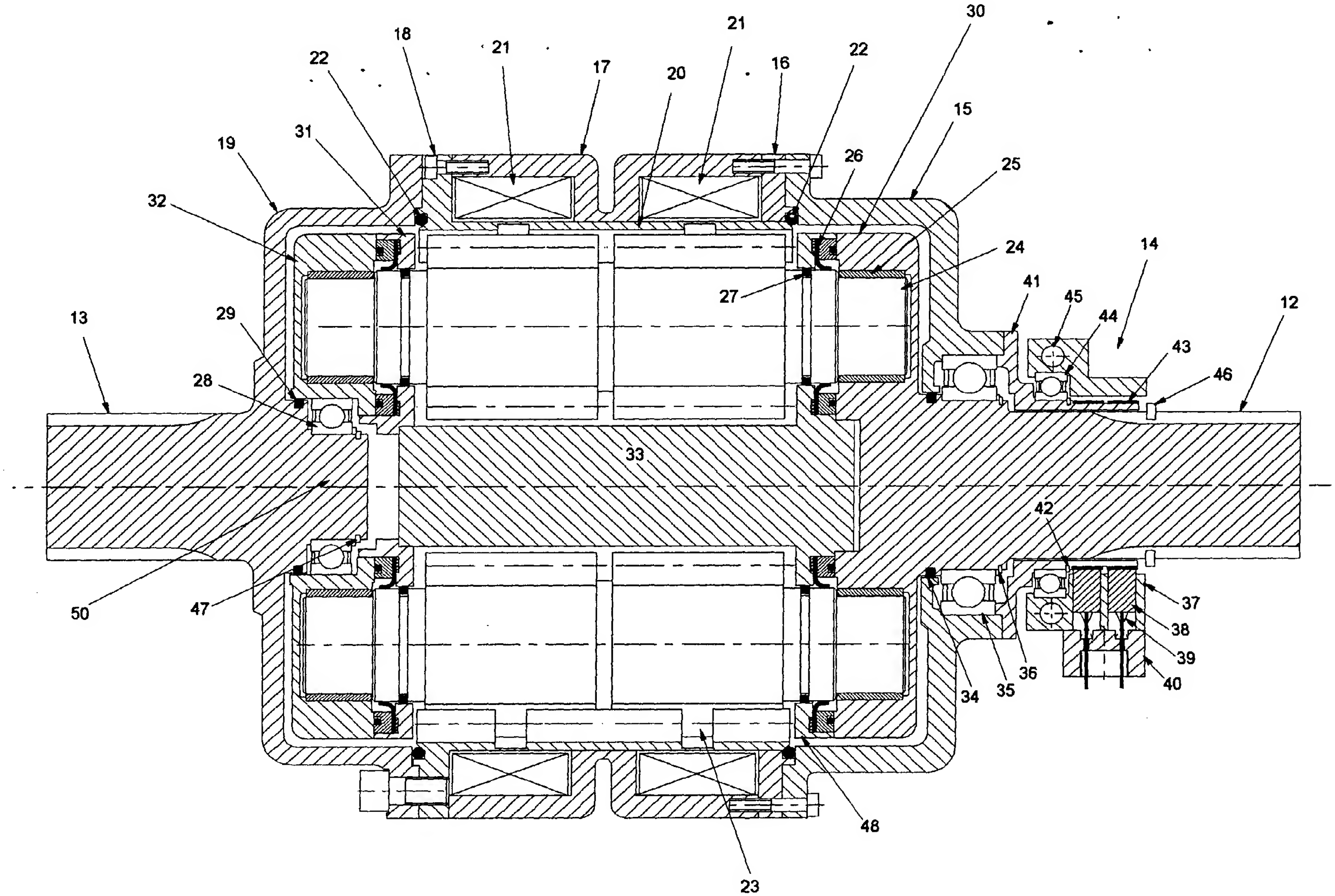

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FIGURE 3

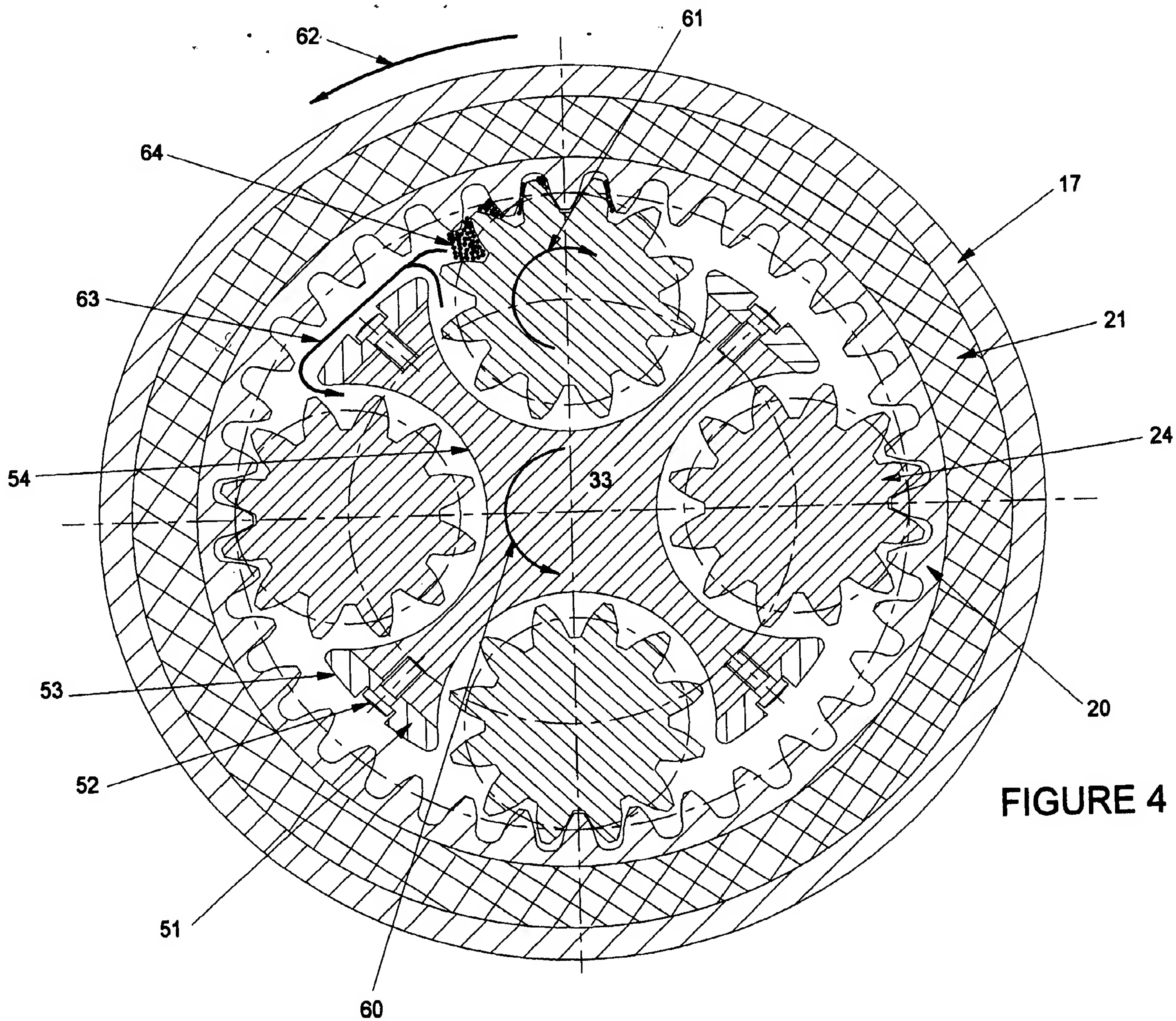

FIGURE 4

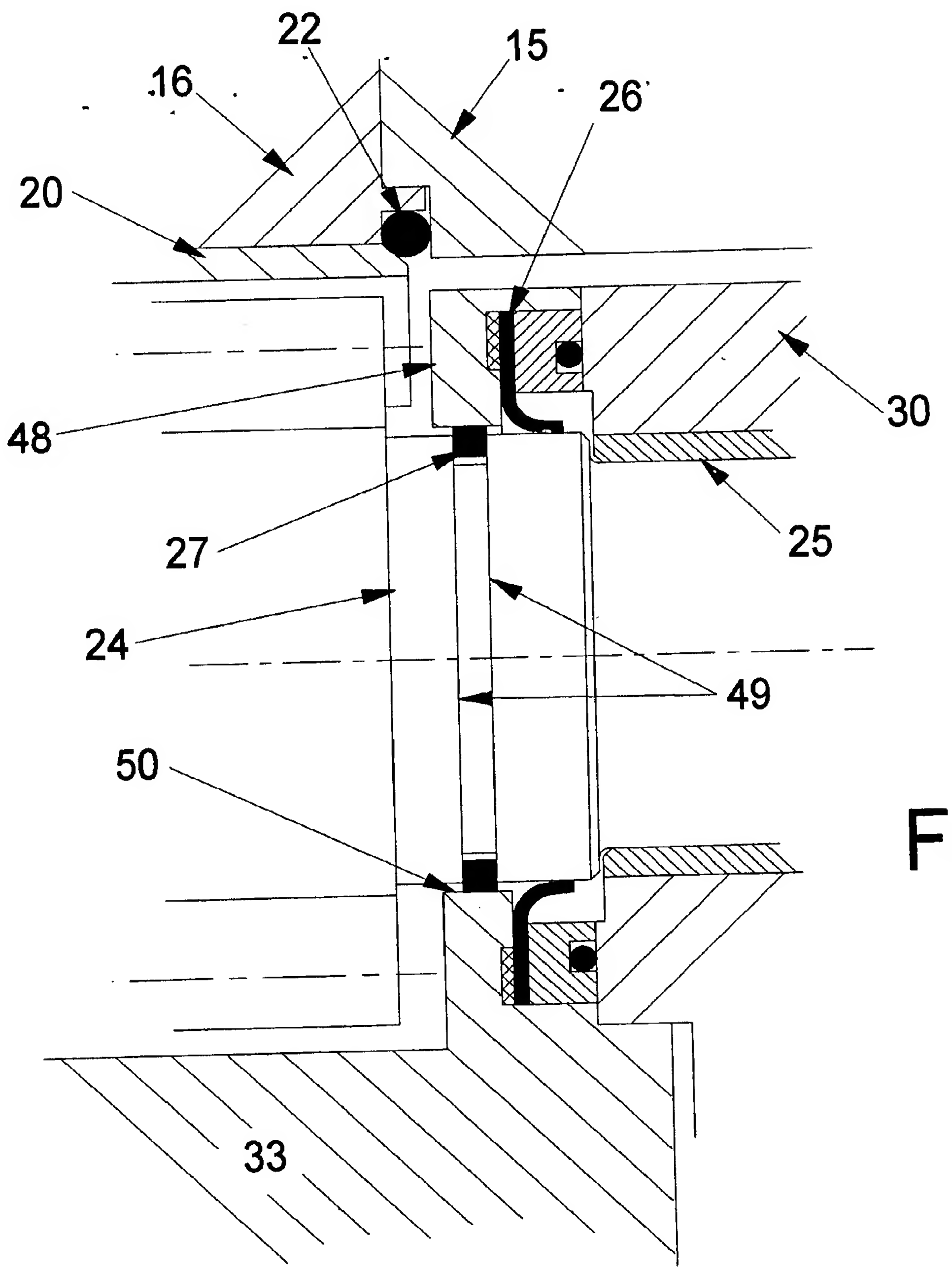

FIGURE 5

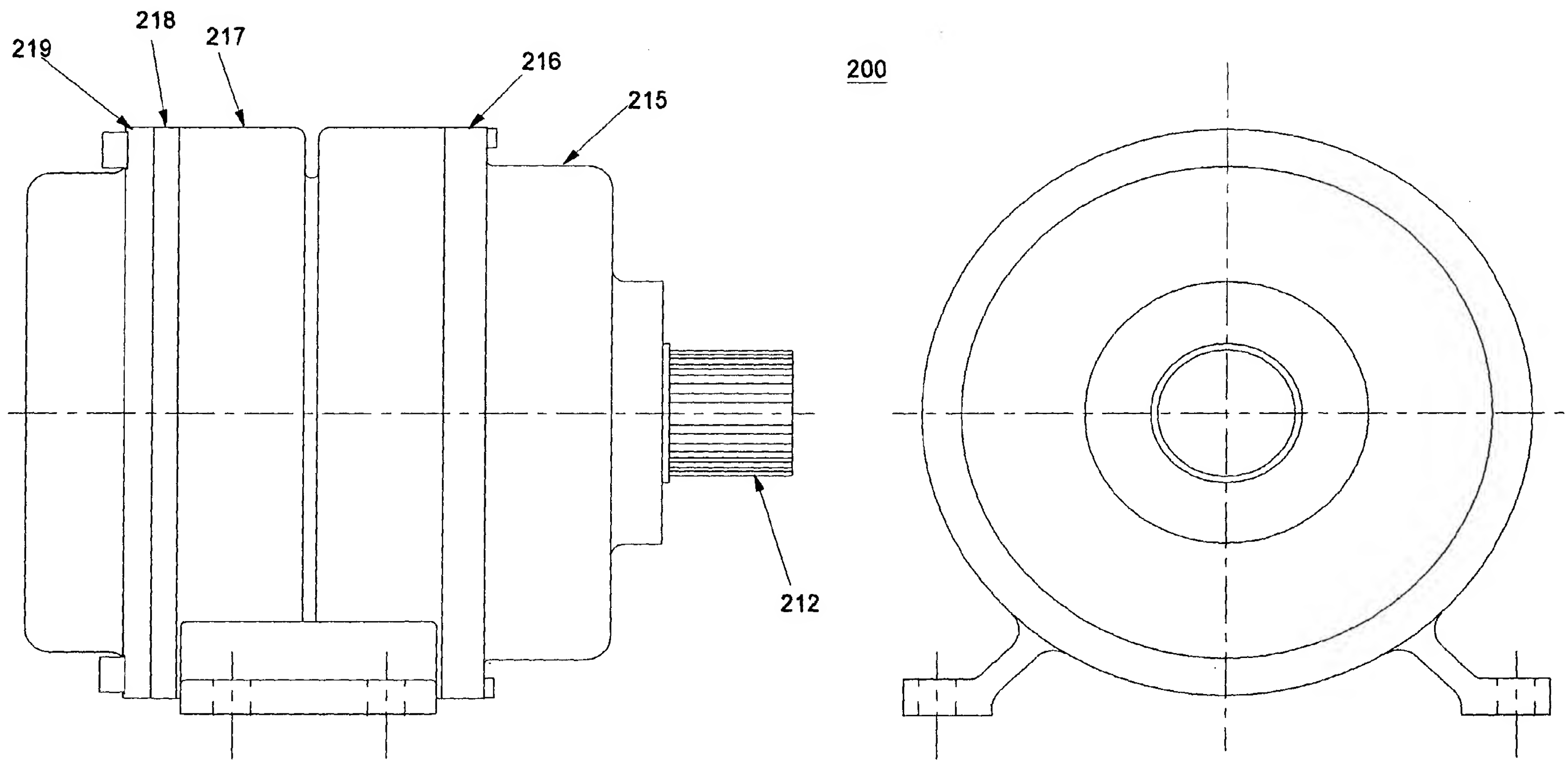

FIGURE 6